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(56) Documents Cited

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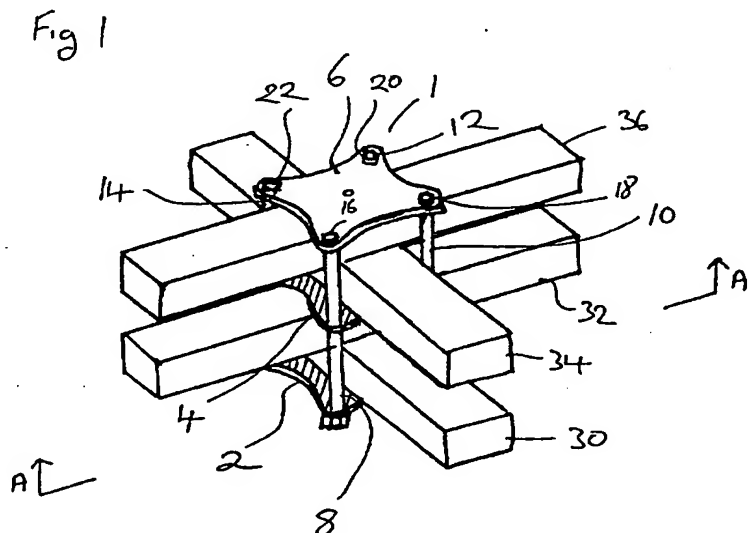
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(74) continued overleaf

(54) Abstract Title

**A coupling and a method of constructing grid shell buildings using such a coupling**

(57) A coupling is provided for use in grid shell building construction. The coupling comprises first, second and third coupling plates (2, 4 and 6) held together by bolts (8, 10, 12 and 14) which serve to define two volumes through which the laths can pass, whilst also keeping them entrained in the volumes such that limited motion between the laths of the grid shell is allowed when the building is being constructed. When the building has achieved its final shape, the coupling is tightened in order to prevent further relative motion of the laths.



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Fig 1

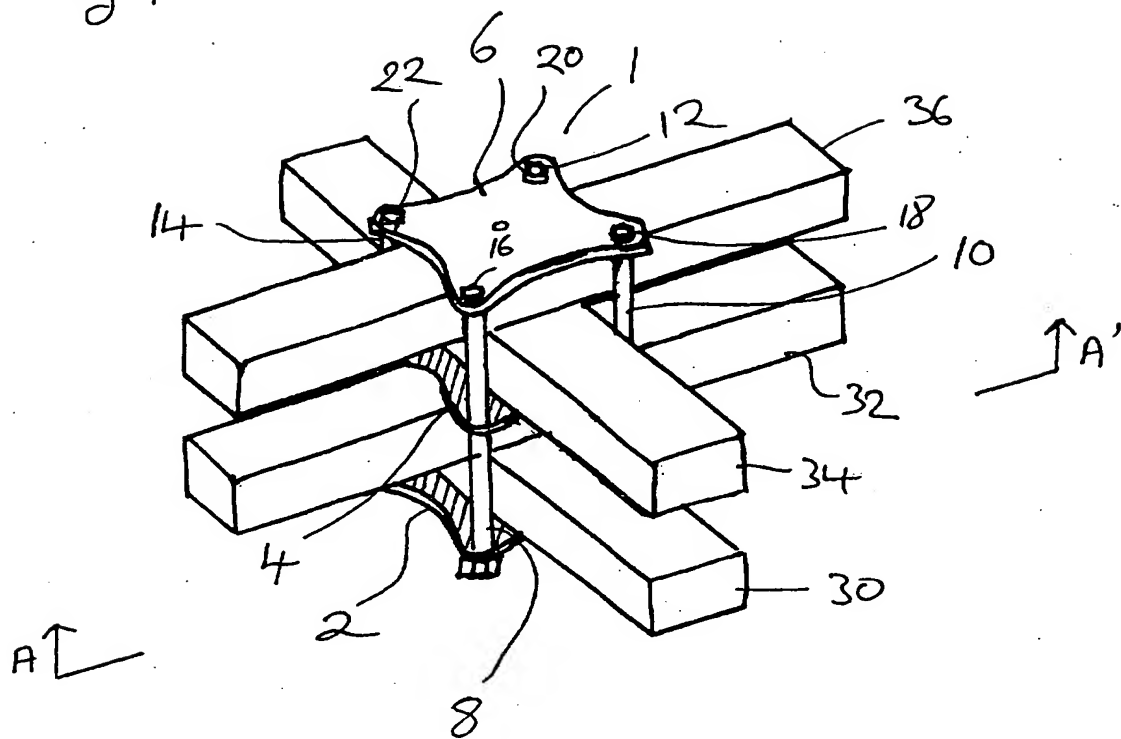


Fig 3

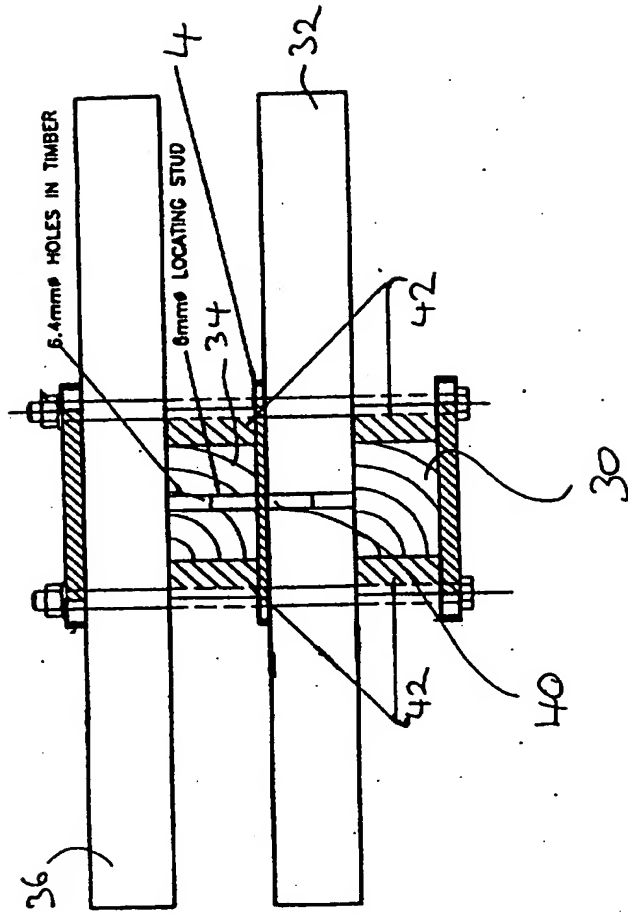
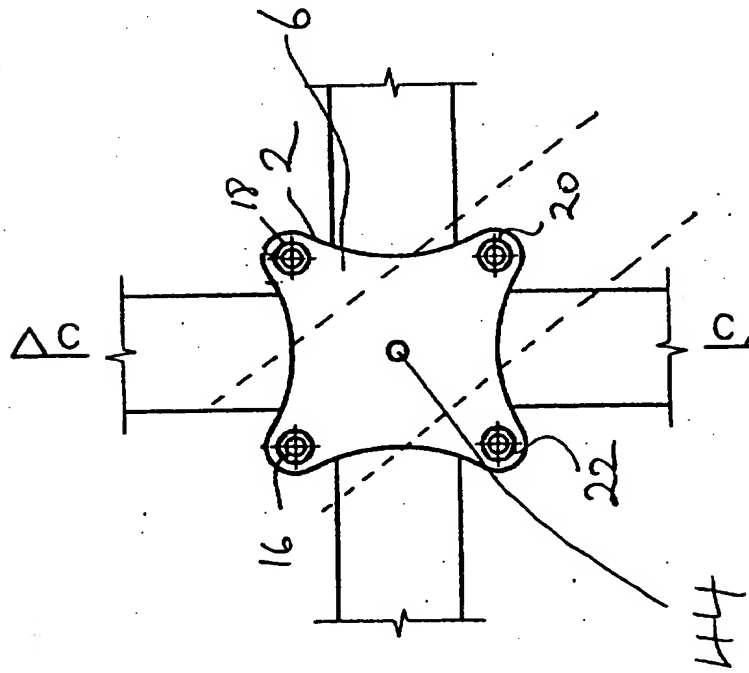


Fig 2



**A COUPLING AND A METHOD OF CONSTRUCTING GRID SHELL  
BUILDINGS USING SUCH A COUPLING**

The present invention relates to a coupling suitable for the construction of timber grid shell structures, and to a method of building such structures using the coupling.

Timber grid shell structures have been known since about the mid 1970's. An array of timbers is used to form a two dimensional planar array. The timbers are arranged such that they are nominally parallel with either one of two perpendicular axes used to define the array. The points where the timbers cross one another are known as "nodes". The nodes need to be secured in such a way that the timbers are held to one another, but that limited motion is permitted. This is because multiple layers of timbers may intersect at a node. As the grid will be deliberately distorted by curving, timbers in different ones of the multiple layers will curve with differing radii of curvature. As a result, the timbers need to be able to slide with respect to one another to account for the effective change in distance between the nodes as a result of this non-uniform bending. This has been done by forming an elongate slot in the timbers at their nodes and passing a bolt through the slots in the timbers. This holds the timbers together but also allows limited motion between the timbers. However this method has the disadvantage that it is relatively expensive and time consuming to form a slot in the timbers at the correct position corresponding to each node. It is also to be noted that the removal of wood to form the slot means that there is less wood available to impart strength to the shell.

Once the array has been constructed, the array (which is known as the grid) is then distorted in a controlled manner to form the shell of a building. The degree and position of the various distortions introduced into the shell needs to be carefully controlled and calculated, but designers have found that a large number of structures can be generated using this constructional technique.

According to a first aspect of the present invention, there is provided a coupling comprising first, second and third coupling elements connectable together by securing elements such

that structural members can pass between the first and second coupling elements, between the second and third coupling elements, and between the securing elements.

It is thus possible to provide a coupling where adjacent coupling elements serve to define a node to retain structural members used in the construction of a grid shell, which permits limited relative motion between the elements, and which avoids the needs to form a groove in the structural elements. This is the advantage of avoiding a relatively costly processing operation during the formation of such a groove.

Preferably the first, second and third coupling elements are arranged in a row. Preferably the coupling elements are arranged in a stacked configuration with the elements being aligned with one another. In a preferred embodiment, the first, second and third coupling elements are substantially identically shaped, and are arranged in a coaxial configuration.

Preferably the securing means extend from the first coupling element to the third coupling element such that the coupling elements can be biased towards one another in order to clamp structural elements therebetween. Advantageously the coupling elements are bolts co-operating with nuts and arranged to extend through apertures formed in each coupling element. However, it would be appreciated that mechanical equivalents, such as studs permanently affixed to and extending from one of the coupling elements could also be used.

Preferably the second coupling element has locating means thereon for engaging with a structural element. The engagement means may be in the form of flanges, studs or other projections which may engage with the side walls of a structural element, with a corresponding mating recess formed therein, or which may penetrate the material of the structural element so as to inhibit relative motion between the structural element and the second coupling element. Preferably the engagement means is an upstanding stud which, in use, becomes forced into the body of the structural element so as to hold it with respect to the second coupling element. Advantageously studs are provided on opposing sides of the second coupling element.

Advantageously either or both of the first and third coupling elements are provided with at least one aperture therein, which optionally may be screw threaded, to facilitate attachment

of other items to the coupling. Such items may include hooks or other items. Additionally, bracing members may also be secured to the coupling via these additional holes. Furthermore, the first, and/or third coupling members may also have outwardly facing engagement means formed thereon in order to facilitate secure engagement to a bracing member.

Further coupling elements may be provided in order to define further regions through which structural members may pass.

According to a second aspect of the present invention, there is provided a method of constructing a grid shell comprising forming structural elements onto a grid, such that a first group of at least two structural elements are held between first and second coupling elements, and a second group of at least two structural elements are held between second and third coupling elements, the first, second and third coupling elements being held together by bolts, and arranged such that coupling elements within a group can slide relative to one another.

The present invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a coupling constituting an embodiment of the present invention;

Figure 2 is a plan view of the coupling along the line A-A' of Figure 1; and

Figure 3 is a side view of the coupling shown in Figure 1.

Referring to the figures, the coupling indicated generally as 1 comprises first, second and third planar coupling elements 2, 4 and 6, respectively, arranged in a stacked configuration. In the embodiment shown, each coupling plate is essentially square, all be it with rounded corners and slightly concave sides. However, these features are primarily cosmetic and do not alter the functionality of the coupling. An aperture is formed in the vicinity of each corner of the plates 2, 4 and 6 such that the apertures themselves define a square array. The apertures define holes for the passage of fixing bolts 8, 10, 12 and 14, respectively, which extend between the first plate 2 and the third plate 6 passing through the holes in the

second plate 4. The bolt is in screw threaded engagement with an associated nut 16, 18, 20 and 22 which enables the compressive force exerted between the plates 2, 4 and 6 to be varied.

In use, wooden laths 30, 32, 34 and 36 are arranged in a planar square array so as to form the starting grid for the structure. The first lath 30 and a second lath 32 are perpendicular to each other and are captured to the first plate 2 and the second plate 4, and also between the paths of the bolts 8, 10, 12 and 14. Similarly a third lath 34 and fourth lath 36 are perpendicular to one another and captured between the second plate 4 and the third plate 6 and again between the bolts 8, 10, 12 and 14. Thus the lateral motion of any lath is restricted by abutment with the bolts, and the degree to which the laths in any pair can separate from one another is restricted by the position of the opposed plates.

In a first embodiment of the coupling, the plates are approximately 105mm<sup>2</sup> and 6mm thick and formed of galvanised steel. Furthermore, once the grid has reached its final configuration additional packing 42 may be forced between the laths and the bolts, as shown in Figure 3, to add further rigidity to the structure where the shearing forces are expected to be particularly high.

As shown in Figure 3, the second plate 4 has a locating stud formed therein which extends above and below the plane of the plate so as to engage in the body of the second and third laths 32 and 34 so as to hold them fixed with respect to the position of the plate. However it is possible to arrange the stud to extend only in one direction if desired so as to only locate on one of the laths. In the embodiment shown in Figure 3, the stud is a diameter of 6mm and can either extend into a pre-drilled hole in the wooden laths (as shown) or may merely punch its own way in due to the compressive forces exerted on the lath as the coupling is done up. Once the grid of the grid shell has been formed, it can then be distorted (by lifting and twisting) in order to form the skeleton of the building. This distortion gives rise to relative motion between the laths in each pair at any given moment. The coupling allows this relative motion to occur, whilst at the same time limiting the degree of motion which any lath can undergo. Once the structure has reached its final shape, the bolts of each coupling are tightened so as to compress the laths together and against the plates of the coupling, thereby holding them steady through frictional

engagement. In this configuration, the grid still forms a basically square or rhombic array. In order to add rigidity to the grid, diagonal bracing members are attached between selected nodes. These diagonal bracing members may be attached to the surface of the innermost or outermost plate 2 or 6 via an additional coupling plate, or screw threaded engagement with the hole 44 formed in the centre of the plates. As a further alternative, selective nodes may be undone and longer bolts inserted such that the diagonal member may, for example, be held between the second and third plates 4 and 6 in conjunction with the laths 34 and 36. The couplings according to the present invention provide a simple yet elegant way of securing the wooden laths of a timber grid shell together in such a way that relative motion between the timbers can be allowed during the construction phase, and the timbers be clamped together inhibiting further relative motion once the shape of the building has been achieved. The use of the clamp also avoids the expensive and time consuming procedure of needing to form grooves through the wooden laths in order that their relative motion can be accommodated. It should be noted that although the description has described the construction of a grid shell having four laths, other numbers of laths may be used depending on the size of the building. If more layers are used, then the coupling can be used in its present form with more than two laths passing between opposed planar coupling elements 2, 4 and 6, and/or further coupling elements may be provided.

**CLAIMS**

1. A coupling comprising first, second and third coupling elements, connectable together by securing elements such that structural members can pass between the first and second coupling elements, between the second and third coupling elements, and between the securing elements.
2. A coupling as claimed in claim 1, in which the first, second and third coupling elements are arranged in a row.
3. A coupling as claimed in claim 1 or 2, in which the first, second and third elements are coaxially arranged.
4. A coupling as claimed in any one of the preceding claims, in which the second coupling element is located intermediate the first and third coupling elements, and has locating means thereon for engaging a structural member.
5. A coupling as claimed in claim 4, in which the second coupling element has engagement means provided on opposite sides thereof.
6. A coupling as claimed in claim 4 or 5, in which the engagement means comprise elements standing proud of the surface of the second coupling element, said engagement means acting to either abut the edges of the structural elements, to engage with a mating recess therein, or extend into the material of the structural element.
7. A coupling as claimed in any one of claim 4 to 6, in which the engagement means is a centrally located upstanding stud.
8. A coupling as claimed in any one of the preceding claims in which at least some of the coupling elements have apertures formed therein for the passage of securing elements therethrough.
9. A coupling as claimed in any one of the preceding claims, in which the coupling elements are held together by screw threaded bolts or studs.

10. A coupling element as claimed in any one of the preceding claims, in which at least two structural members are, in use, held between opposing coupling elements.
11. A coupling element as claimed in any one of the preceding claims, in which at least one of the first and third coupling elements further includes attachment means for attaching diagonal bracing elements to the coupling.
12. A method of constructing a grid shell comprising forming structural elements onto a grid, such that a first group of at least two structural elements are held between first and second coupling elements, and a second group of at least two structural elements are held between second and third coupling elements, the first, second and third coupling elements being held together by bolts, and arranged such that coupling elements within a group can slide relative to one another.
13. A method as claimed in claim 12, in which, after the grid shell has been manipulated into a desired shape, the bolts are tightened to cause the coupling elements to clamp the structural elements together.



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INVESTOR IN PEOPLE

Application No: GB 0009626.3  
Claims searched: 1 to 13

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Examiner: John Twin  
Date of search: 30 October 2000

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): E2A (AGB, AGKFH)

Int Cl (Ed.7): E04B 1/26, 1/58; E04C 5/16; F16B 7/04

Other: online: EPODOC, JAPIO, WPI

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 998908 (Coppell) - see eg fig.12	1 at least
X	GB 744495 (Naylor)	1 at least
X	GB 627989 (Agricultural Supplies)	1 at least
X	FR 2404139 A (Clement) - see WPI abstract accession no.1979-F6066B	1 at least

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